Scope of Work and Schedule for the Bear Creek Watershed–Scale Stormwater Plan

November 2015

King County

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Scope of Work and Schedule for the Bear Creek Watershed–Scale Stormwater Plan

Prepared for:

Washington State Department of Ecology, NPDES Phase I Permit compliance (S5.C.5.c.iv) and Phase II Permit Compliance (S5.C.4.g.ii)

Submitted by:

King County, Water and Land Resources Division,
Department of Natural Resources and Parks
NPDES Permit #WAR04-4501

Submitted for:

Snohomish County, Department of Public Works
NPDES Permit #WAR04-4502

City of Redmond, Department of Public Works
NPDES Permit #WAR04-5538

City of Woodinville, Department of Public Works
NPDES Permit #WAR04-5545

Washington State, Department of Transportation
NPDES Permit #WAR04-3000A

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EXECUTIVE SUMMARY

King County is required to conduct a watershed-scale stormwater planning effort to satisfy permit obligations under section S5.C.5.c of the National Pollutant Discharge Elimination System Phase I Municipal Stormwater Permit (permit) issued by the Washington State Department of Ecology (Ecology), effective August 1, 2013 through July 31, 2018, and modified January 16, 2015. This Scope of Work submitted by King County and its project partners (i.e., Snohomish County, Cities of Redmond and Woodinville, WSDOT) is intended to meet the requirements in section S5.C.5.c.iv of the permit, but requires Ecology approval.

King County's long-term goal of this Watershed Plan is to restore Bear Creek so that it provides healthy aquatic habitat for chinook salmon and other species now and into the future. The objective for this watershed-scale planning effort that will support reaching this goal is to identify a suite of management strategies that would result in hydrologic and water quality conditions that fully support *existing* and *designated uses,* as defined in the Washington Administrative Code (WAC 173-201A-020).

Bear Creek contains many miles of high-quality aquatic resources, and is known to support a wide range of salmonids, including Chinook—an ESA listed "threatened" species. Recently, the Bear Creek watershed was identified by Ecology as a target watershed for stormwater retrofit planning because of its *high integrity* (as defined by Ecology). For this reason, King County selected the Bear Creek watershed for the watershed-scale stormwater planning effort as specified in the permit (S5.C.5.c.i). Ecology approved King County's request to select a sub-area of the Bear Creek basin to meet permit requirements S5.C.5.c.i.(1) through S5.C.5.c.i.(4). This sub-area is defined as Bear Creek drainage areas above the confluence of Evans Creek tributary and excludes Cottage Lake and its drainage basin. This planning area approximately totals 26 square miles and includes area within four other jurisdictions: City of Redmond (2.4 square miles); City of Woodinville (1.1 square miles); Washington State Department of Transportation (0.003 square miles); and Snohomish County (3.7 square miles); in addition to unincorporated King County (18.9 square miles).

King County will lead the planning process (S5.C.5.c.ii) and coordinate (S5.C.5.c.iii) with the participating Permittees (King County, Snohomish County, City of Redmond, City of Woodinville, and Washington State Department of Transportation) as described in the coordination document, *Coordination Plan for NPDES Phase I & II Bear Creek Watershed-Scale Stormwater Plan* (July 29, 2015), for permit compliance.

King County will conduct stakeholder workshops and public meetings to allow for additional input during the implementation of this Scope of Work. The public and stakeholders will have an opportunity to review and comment on the draft watershed plan prior to final submission.

The watershed-scale plan will include assessments of the landscape based on historic, existing, and projected future conditions. Stormwater management strategies will be evaluated, using these landscape baselines, for stream health based on stream hydrology, water quality, and aquatic biota (life forms). The evaluations will be derived from previous study results; interpretation of existing and new data; and development of hydrologic models that will project historic and future conditions and characterize what is needed to restore Bear Creek.

An implementation plan (or plans) will be drafted using these results, which will include stormwater management strategies, estimated costs, and potential funding mechanisms.

The permit required deliverables for this watershed planning process are:

- Notifying Ecology on King County's selection of a watershed by October 31, 2013 (complete)
- Submittal of a Coordination plan that is agreed to by all participating Permittees by August 13, 2015 (complete)
- Submittal of this Scope of Work by November 4, 2015 (this document, pending Ecology approval)
- Submittal of a Watershed-Scale Stormwater Plan by April 4, 2018.

1.0. INTRODUCTION

King County's long-term goal of this Watershed Plan is to restore Bear Creek so that it provides healthy aquatic habitat for Chinook salmon and other species now and into the future.

King County's specific objectives for this planning effort are as follows:

- Demonstrate the ability of multiple jurisdictions to collaborate in on a watershed basis, focusing and coordinating multijurisdictional efforts to restore Bear Creek.
- Holistically asses existing conditions of in-stream habitat, near shore buffer integrity, and watershed/stormwater characteristics.
- Model existing conditions and future conditions to estimate both hydrologic and water quality issues.
- Model potential solution suites to identify what needs to occur to eliminate adverse impacts of stormwater and restore Bear Creek while being realistic of economic constraints. Solutions may include stormwater retrofits, in-stream projects, buffer enhancement projects, program implementation, and policy changes.
- Collaboratively develop an implementation plan that transcends jurisdictional boundaries that is realistic and achievable by all local governments involved.

King County is required to conduct a watershed-scale stormwater planning effort to satisfy permit obligations under section S5.C.5.c of the National Pollutant Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit (permit) issued by the Washington State Department of Ecology (Ecology), effective August 1, 2013 through July 31, 2018, and modified January 16, 2015. The modified permit requires a Scope of Work for this project to be submitted for approval by November 4, 2015. This Scope of Work and schedule was developed in collaboration with participating Permittees (i.e., Snohomish County, the City of Redmond, and the City of Woodinville). Washington State Department of Transportation does not have a permit requirement to submit a Scope of Work for a watershed plan, but has also collaborated in development of this document. This Scope of Work and schedule has been submitted for Ecology's approval under section S5.C.5.c.iv for Phase I Permittees (King and Snohomish Counties) and S5.C.4.g.ii for Phase II Permittees (Cities of Redmond and Woodinville).

1.1 Bear Creek Watershed

King County selected the Bear Creek watershed for the watershed-scale stormwater planning effort. For watershed-scale stormwater planning purposes, the Bear Creek watershed is defined as including Bear Creek and lands that drain to Bear Creek, with the following exclusions:

- The Evans Creek basin (a tributary to Bear Creek) is not included in King County's selection

- The reach of Bear Creek downstream of the confluence to Evans Creek, along with small direct drainages and tributaries to this reach of Bear Creek
- Cottage Lake and the area that drains to Cottage Lake

King County's selection of the Bear Creek watershed, as defined above, was approved by Ecology (NPDES Phase I permit, S5.C.5.c.i). This basin (Figure 1) encompasses approximately 26 square miles. About 2.5 square miles (10 percent) are in the City of Redmond, 1.1 square miles (4 percent) are in the City of Woodinville, 1.9 acres (0.01 percent) are owned by the Washington State Department of Transportation, 3.4 square miles (13 percent) are in unincorporated Snohomish County, and 18.9 square miles (73 percent) are in unincorporated King County. The majority of the unincorporated King County area is designated rural except for about 1.9 square miles residing on the urban side of the Urban Growth Boundary (Figure 1). However, a large portion of the study area including unincorporated areas (39%) have existing parcel densities greater than rural zoning RA 2.5 (Figure 2).

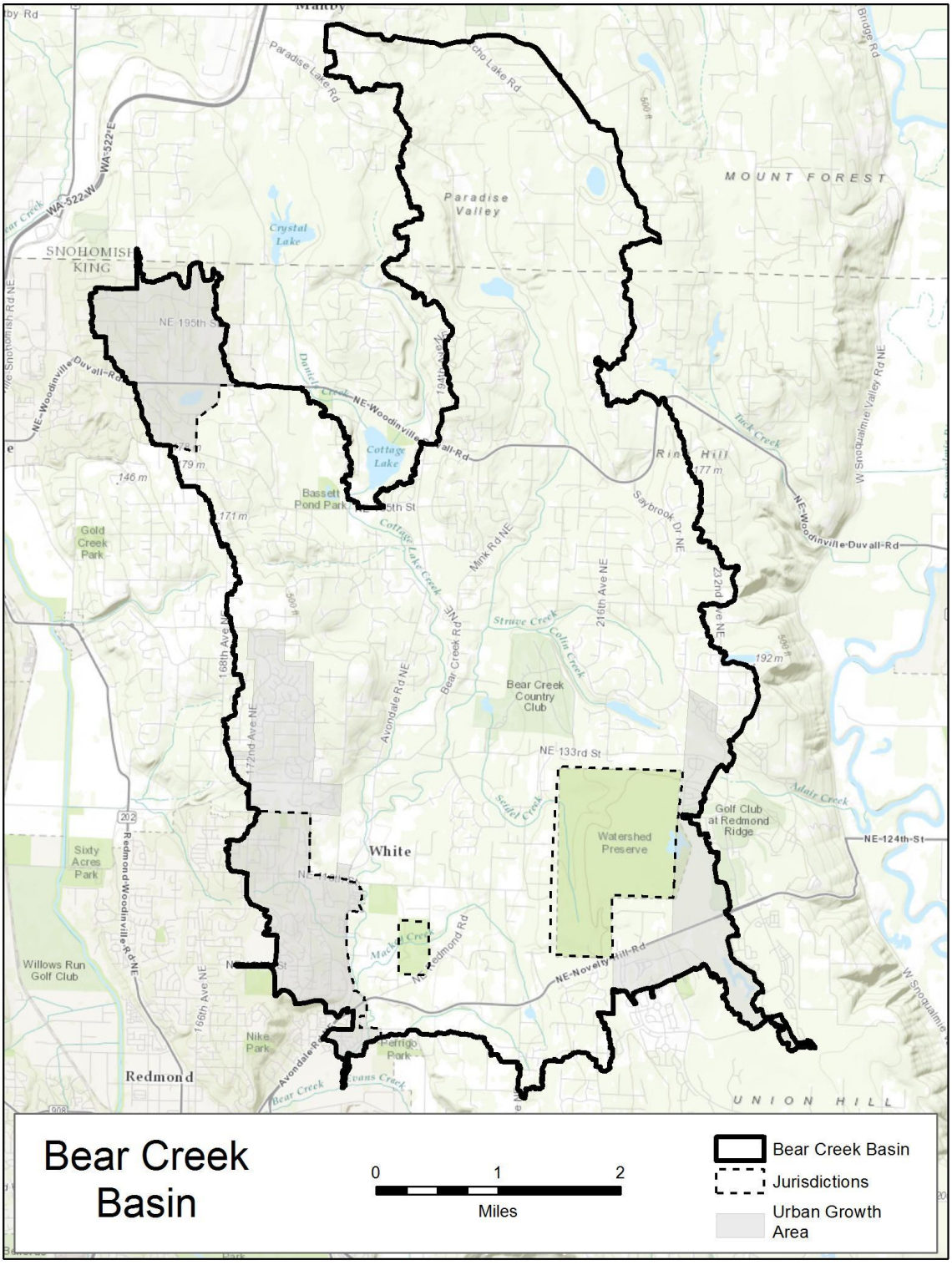

Figure 1. Bear Creek Study Area – Scale Stormwater Planning Area

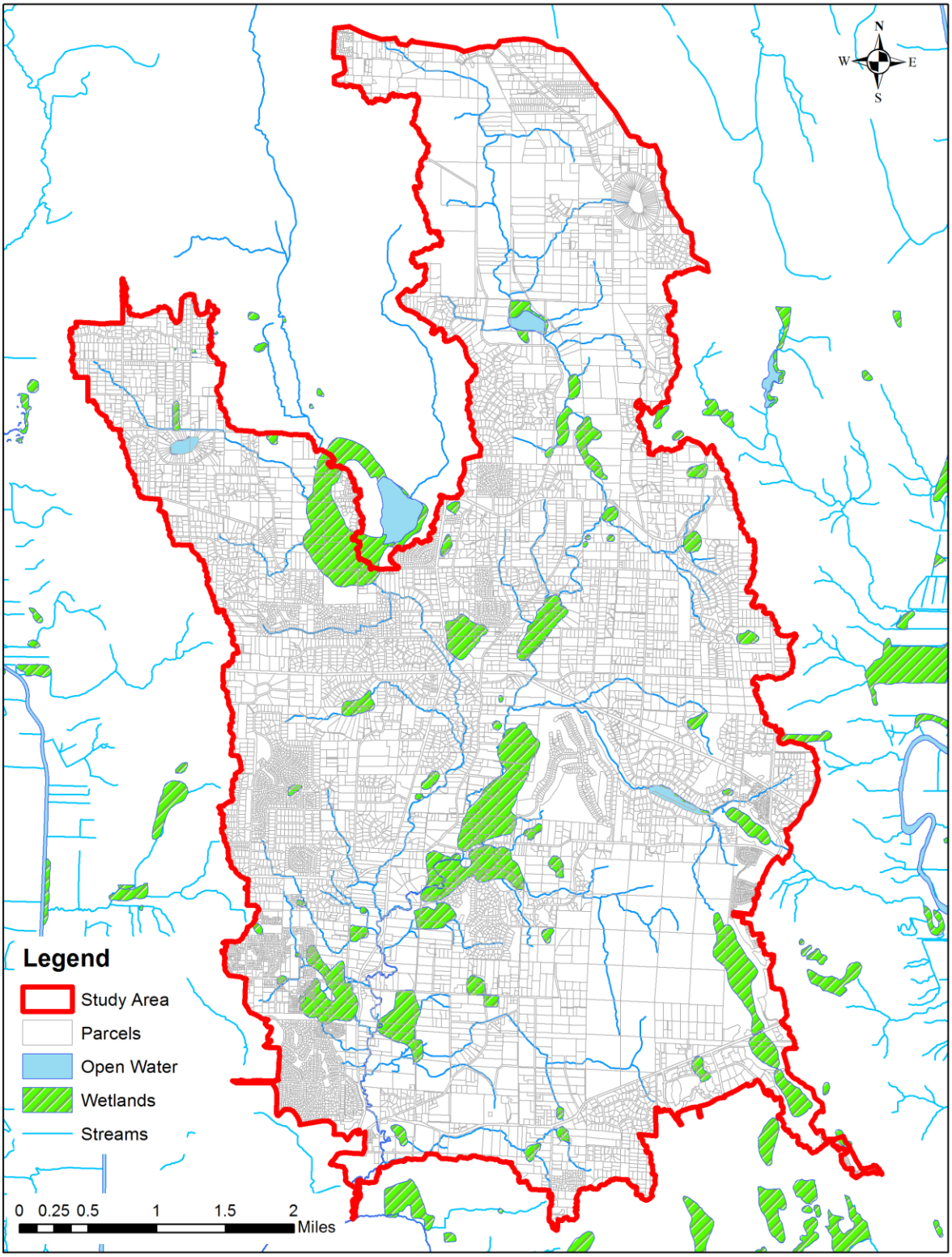

Figure 2. Bear Creek study area – parcel delineations and wetlands

Substantial development has already occurred, and more is expected in the Bear Creek watershed. The study area currently supports an estimated population of about 27,000[1]. Land use, based on satellite imagery from 2007, is comprised largely of a mixture of light urban, medium urban, deciduous/ mixed forest, and grass (Figure 3). Modeled 2040 land use conditions, assessed using a land cover change model (LCCM) and an urban socio-economic and transportation model (UrbanSim) set to run a "business as usual" scenario based on existing zoning and regulations and projected population growth[2], show a substantial shift to heavy urban and medium urban land use by 2040 due primarily to population growth in the urban areas and increased impervious area associated with redevelopment in the rural areas (Figure 4). This shift in land use demonstrates the substantial growth pressures anticipated in this basin [S5.C.5.c.i.(4)].

[1] Puget Sound Regional Council 2013 Forecast Products (http://www.psrc.org/data/forecasts/2013-forecast-products/)

[2] Population is projected to increase to 31,500 in the study area by 2035 (PSRC 2013)

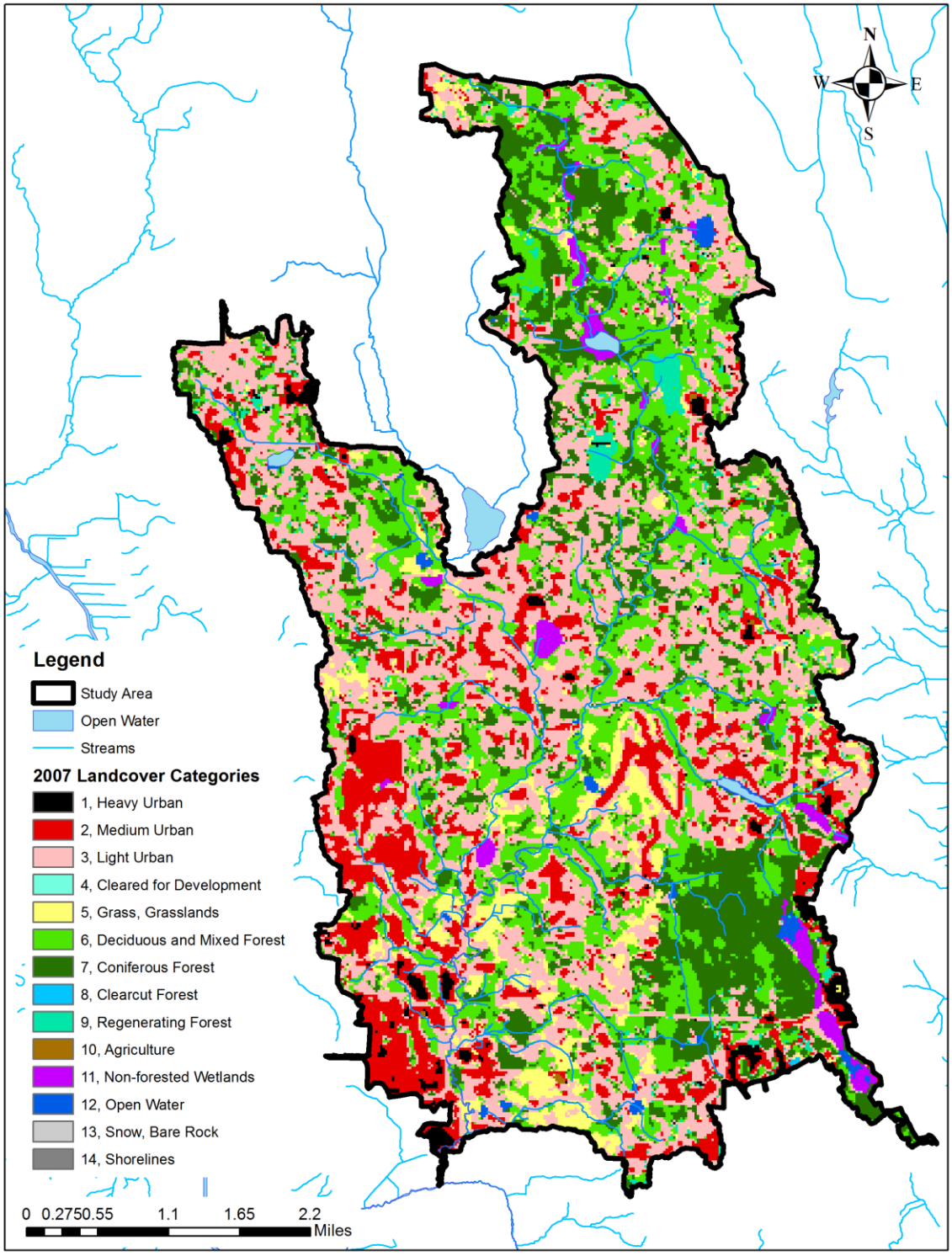

Figure 3. Bear Creek study area 2007 Land Use and Land Cover[3]

[3] University of Washington. 2007. Central Puget Sound 2007 Land Cover Classification. Puget Sound Regional Synthesis Model (PRISM). University of Washington.

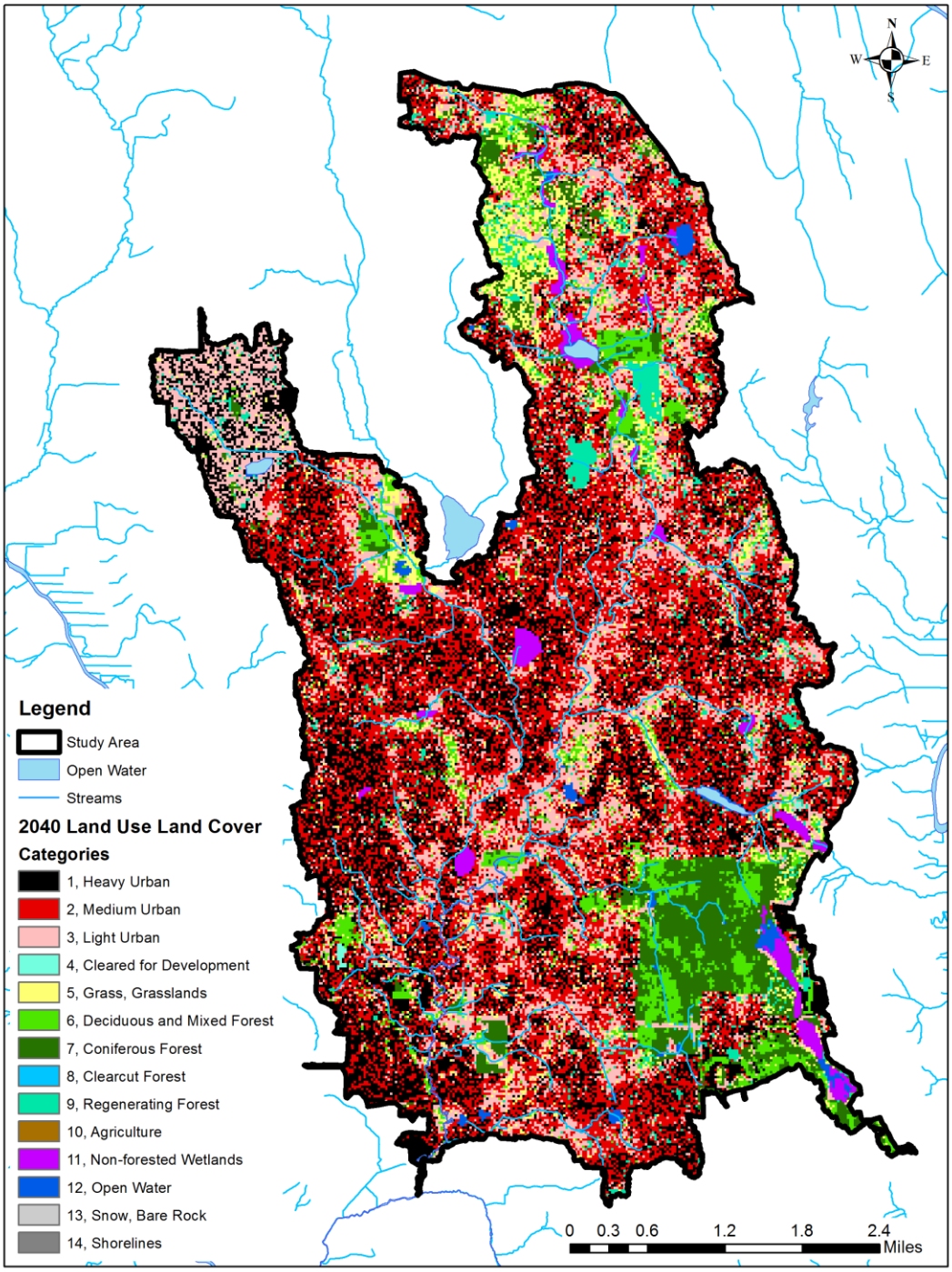

Figure 4. Simulated 2040 Bear Creek Study Area Land Use and Land Cover[4]

[4] Alberti, Marina. 2009. NSF Biocomplexity II Grant. 2005-2009. Urban Landscape Patterns: Complex Dynamics and Emergent Properties. Dr. Marina Alberti, Principal Investigator Projections in City of Woodinville's jurisdiction were adjusted to better reflect zoning limits on impervious surfaces.

Even with the current population, Bear Creek contains many miles of high-quality aquatic resources, and is known to support a wide range of salmonids, including chinook[5], sockeye, coho, kokanee, and coastal cutthroat[6] [S5.C.5.c.i.(3)]. Recently, the Bear Creek watershed was identified by Ecology as a target watershed for stormwater retrofit planning[7], with a watershed integrity index of 9 on a scale of 1 (low integrity) to 9 (high integrity). An integrity index of 9 characterizes the basin as a high value resource and high potential to be restored. Completing a watershed-scale stormwater plan for Bear Creek is a step toward preserving and restoring these aquatic resources.

1.2 Previous Studies

Numerous studies have been conducted in the Bear Creek watershed. These studies will provide foundational material for this project. Some examples include:

Fevold, K. and J. Vanderhoof. 2002. Freshwater Mussels Found in Bear and Cottage Lake Creeks During Habitat Assessments in 2001.

Kerwin, J. 2001. Salmon and Steelhead Limiting Factors Report for the Cedar-Sammamish Basin (Water Resource Inventory Area 8). Washington Conservation Commission. Olympia, WA.

King County. 1995. Bear Creek Basin Plan. The basin plan, adopted by the King County Council, covered the entire basin.

King County. 2002. Water Quality Monitoring of Northern Lake Washington Streams. Water and Land Resources Division. Seattle, Washington.

King County. 2004. Benthic Macroinvertebrate Study of the Greater Lake Washington and Green-Duwamish River Watersheds Year 2002 Data Analysis. Submitted by EVS Environmental Consultants. Water and Land Resources Division, Seattle, Washington.

King County. 2005. Benthic Macroinvertebrate Study of the Greater Lake Washington and Green-Duwamish River Watersheds Year 2003 Data Analysis. Submitted by EVS Environmental Consultants. Water and Land Resources Division, Seattle, Washington.

[5] ESA listed as threatened species.
[6] Kerwin, J., 2001. Salmon and Steelhead Habitat Limiting Factors Report for the Cedar - Sammamish Basin (Water Resource Inventory Area 8). Washington Conservation Commission. Olympia, WA
[7] Assessed by Ecology in support of National Estuary Program Watershed Protection & Restoration Grant Program 2013 (http://www.ecy.wa.gov/puget_sound/docs/grants/2013StormwaterRetrofitTargetWatershedIDMethods.pptx)

King County. 2005. Results of a Pilot Freshwater Mussel Survey in King County. Prepared by Bob Brenner. Water and Land Resources Division. Seattle, Washington.

King County. 2006. Timing, abundance, and population characteristics of spawning Chinook salmon in the Cedar/Sammamish Watershed. Prepared by Hans B. Berge and Mistie L. Hammer, King County Department of Natural Resources and Parks, and Steve R. Foley, Washington Department of Fish and Wildlife—Region 4.

King County. 2007. Cold Creek Aquifer Study of Surface Water / Groundwater Interactions, Phase 2. Prepared by Sevin Bilir, Water and Land Resources Division. Seattle, Washington.

King County. 2010. Working Draft Identification of Streams with Declines in Summer Low Flows. Prepared by Curtis DeGasperi and Jeff Burkey, Water and Land Resources Division. Seattle, Washington.

King County. 2010. Working Draft Preliminary Estimates of Summer Environmental Restoration Flow Targets for Basins in King County with Declines in Summer Low Flows. Prepared by Curtis DeGasperi and Jeff Burkey, Water and Land Resources Division. Seattle, Washington.

King County. 2012. Stormwater Retrofit Analysis for Juanita Creek Basin in the Lake Washington Watershed. Ecology Grant: G0800618. Prepared by Jeff Burkey, Mark Wilgus P.E., and Hans Berge. King County Department of Natural Resources and Parks. Water and Land Resources Division. Seattle, Washington.

King County. 2013. Watershed Model Development for Water Resource Inventory Area (WRIA) 9 Stormwater Retrofit Planning Project. Prepared by Jeff Burkey, Science and Technical Support Section in Water and Land Resources Division, Department of Natural Resources and Parks. Seattle, Washington.

King County. 2014. Development of a Stormwater Retrofit Plan for Water Resources Inventory Area 9: Comprehensive Needs and Cost Assessment and Extrapolation to Puget Sound. Prepared by Jim Simmonds and Olivia Wright, Water and Land Resources Division. Seattle, Washington.

King County. 2014. Identifying stressor risk to biological health in streams and small rivers of western Washington. Prepared by Elene Dorfmeier, King County Department of Natural Resources, Water and Land Resources Division. Seattle, Washington.

King County. 2015. Monitoring for Adaptive Management: Status and Trends of Aquatic and Riparian Habitats in the Lake Washington/Cedar/Sammamish Watershed (WRIA 8). King County Water and Land Resources Division. Seattle, Washington.

Kiyohara, Kelly. 2013. Evaluation of Juvenile Salmon Production in 2012 from the Cedar River and Bear Creek. Prepared by Kelly Kiyohara, Science Division, Fish Program, Washington Department of Fish and Wildlife. Olympia, Washington.

Kiyohara, Kelly. 2015. Evaluation of Juvenile Salmon Production in 2014 from the Cedar River and Bear Creek. Prepared by Kelly Kiyohara, Science Division, Fish Program, Washington Department of Fish and Wildlife. Olympia, Washington.

Lee, Sinang, 2008. Bear-Evans Watershed Fecal Coliform Bacteria Total Maximum Daily Load—Water Quality Improvement Report. Prepared for Washington State Department of Ecology. Publication No. 08-10-026. Prepared by Sinang H. Lee, Water Quality Program, Northwest Regional Office, Washington State Department of Ecology. Bellevue, Washington.

Massmann, J. 2000. Effects of Groundwater Extraction on Stream Flow in Bear-Evans Creek Watershed. Prepared for The Muckleshoot Indian Tribe, Fisheries Department. Auburn, Washington.

Mohamedali, T., S. Lee. 2008. Bear-Evans Watershed Temperature and Dissolved Oxygen Total Maximum Daily Load—Water Quality Improvement Report. Prepared for Washington State Department of Ecology. Publication No. 08-10-058. Prepared by Teizeen Mohamedali, Environmental Assessment Program (Olympia) and Sinang H. Lee, Water Quality Program, Northwest Regional Office (Bellevue), Washington State Department of Ecology. Olympia, Washington. www.ecy.wa.gov/biblio/0810058.html

Roberts, M. and R. Jack. 2006. Sampling and Analysis Plan and Quality Assurance Project Plan—Bear/Evans Watershed Temperature and Dissolved Oxygen Total Maximum Daily Load Study. Prepared for Washington State Department of Ecology. Publication No. 06-03-107. Prepared by Dr. Mindy Roberts, Environmental Assessment Program, Olympia, Washington, and Richard Jack, King County Department of Natural Resources and Parks. Seattle, Washington. www.ecy.wa.gov/biblio/0603107.html

Thomas, A.C. 2008. Investigation of Western Pearshell Mussel (*Margartifera falcata*) Mortality in Bear Creek, King County, Washington: A Disease Ecology Approach. University of Washington.

Vanderhoof, J., S. Stolnack, K. Rauscher, and K. Higgins. 2011. Lake Washington/Cedar/ Sammamish Watershed (WRIA 8) Land Cover Change Analysis. Prepared for WRIA8 Technical Committee by King County Water and Land Resources Division, Department of Natural Resources and Parks. Seattle, Washington

WRIA 8 Steering Committee, 2005. Final—Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan, Volumes I-III. Prepared by the WRIA 8 Technical Committee.

2.0. TASKS

Project tasks follow the requirements specified in the NPDES permit.

2.1 Task 1: Assessment of Existing Conditions

Assessment of existing conditions [S5.C.5.c.ii.(1)] are detailed by task.

2.1.1 Task 1a: Water Quality

Substantial water quality monitoring data are available for the Bear Creek watershed [S5.C.5.c.iv.(1).a]. These data include:

- Monthly water quality monitoring for conventional parameters[8], nutrients, and bacteria at two Bear Creek locations within the study area from 1974 through present. Two more monitoring stations with similar periods of record exist; one approximately 6000-ft downstream of the study area, and the other approximately 4000-ft upstream of the study area on Evans Creek. (Figure 5).
- A study to assess stream temperature and dissolved oxygen was completed in 2006[9] in support of the development of a Total Maximum Daily Load (TMDL) for temperature and dissolved oxygen. Eighteen of those monitoring stations were within this project's study area collecting continuous data between June and October 2006.

No dissolved copper or dissolved zinc data are available in the project area. Downstream of the project area, dissolved copper and dissolved zinc data are available in Bear Creek below the confluence with Evans Creek.

As part of this project, a quality assurance and project plan (QAPP) has been developed defining monitoring station locations, types of data, collection methods, field and lab analyses performed, and prescribing quality control measures to ensure sufficient accuracy for use supporting watershed model development. The water quality monitoring program will include monitoring upstream and downstream of stream sections influenced by discharges from King County's municipal separate storm sewer system (MS4). Monitoring began at some locations in 2014 and is expected to conclude in January 2016.

There are 12 continuous water temperature monitoring stations co-located with continuous flow gaging stations during the monitoring period (June 2014 through January 2016). Available data from these monitoring stations may be limited due to, for example, equipment failure, equipment vandalization, too low of flow rates, etc.

[8] Conventional parameters include: water temperature, pH, conductivity, dissolved oxygen, total suspended solids, and turbidity.

[9] Roberts, M. and Jack, R. 2006. Sampling and Analysis Plan and Quality Assurance Project Plan—Bear/Evans Watershed Temperature and Dissolved Oxygen Total Maximum Daily Load Study. Prepared by Dr. Mindy Roberts, Environmental Assessment Program, Washington Department of Ecology, Olympia, Washington, and Richard Jack, Water and Land Resources Division, King County Department of Natural Resources and Parks, Seattle, Washington.

There are thirteen locations that will be sampled during 6 stormflow and 6 baseflow conditions between June 2014 and January 2016, although the exact number of locations and samples may be altered in response to unforeseen constraints (e.g., lack of property access, insufficient stream flow, equipment failures, etc.). Three grab samples will be collected during storm events and one to two grab samples will be collected during base flow events. Time intervals between grab samples during storm events are intended to capture conditions during the rising limb, near the peak, and the falling limb of the hydrograph. However, each storm event can be unique making it very difficult to achieve all of these conditions. For example, if a storm happens to be longer or shorter in duration than anticipated, when the sample is collected and where it falls on the hydrograph may not align with the previous stated goals (i.e., on the hydrograph rising, peak, and falling limbs). Grab samples will be collected instantaneously and analyzed at the lab at a minimum for fecal coliform bacteria, total and dissolved copper, total and dissolved zinc, hardness, and total suspended solids. Optional analyses likely to be performed include: turbidity, nitrogen, and with more limited sample collection and analysis including particle size distributions on total suspended sediments(TSS) (sand, silt, clay) and stream beds (via sieve analysis) to support watershed model development.

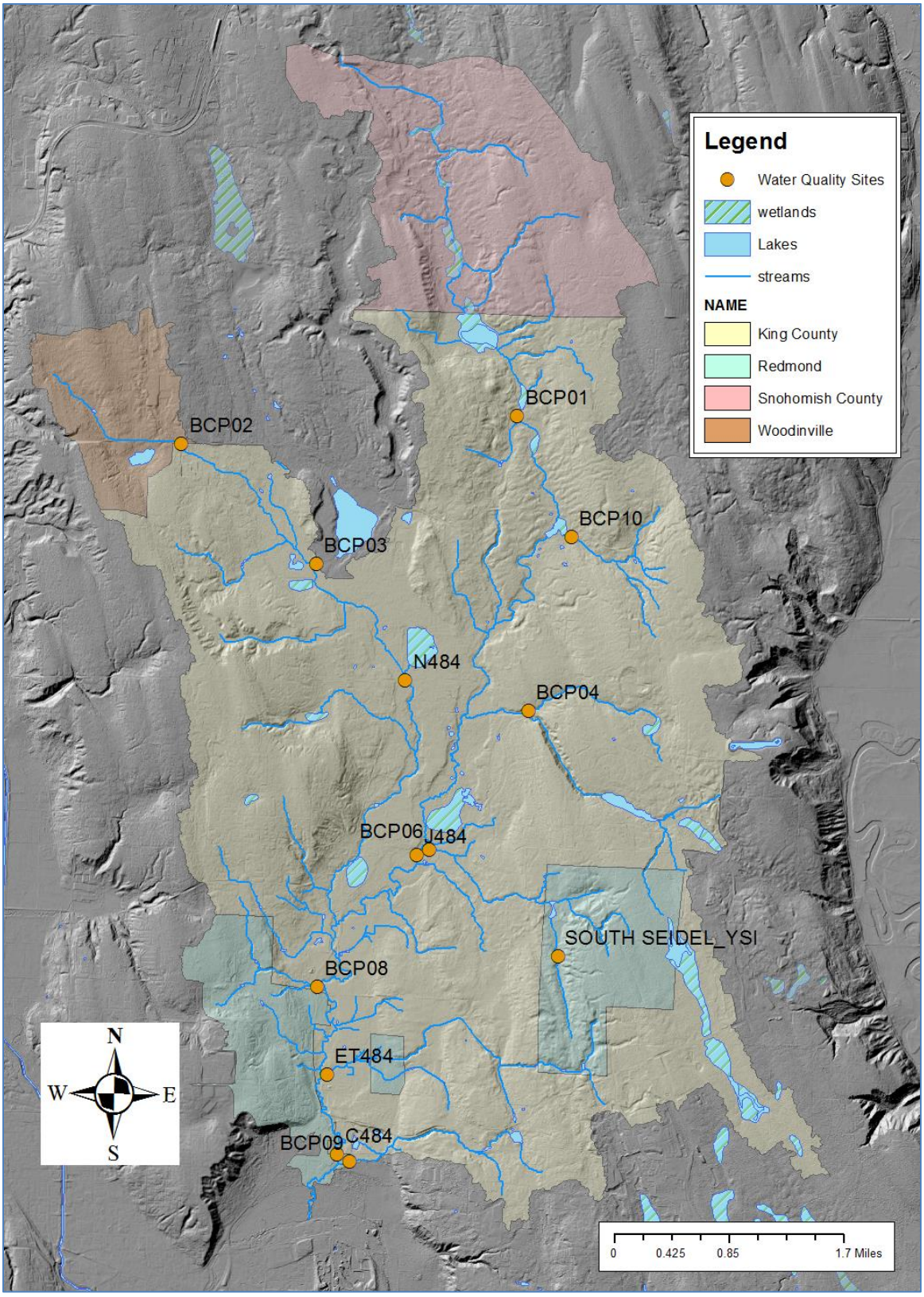

Figure 5. Bear Creek Study Area Water Quality Monitoring Locations.

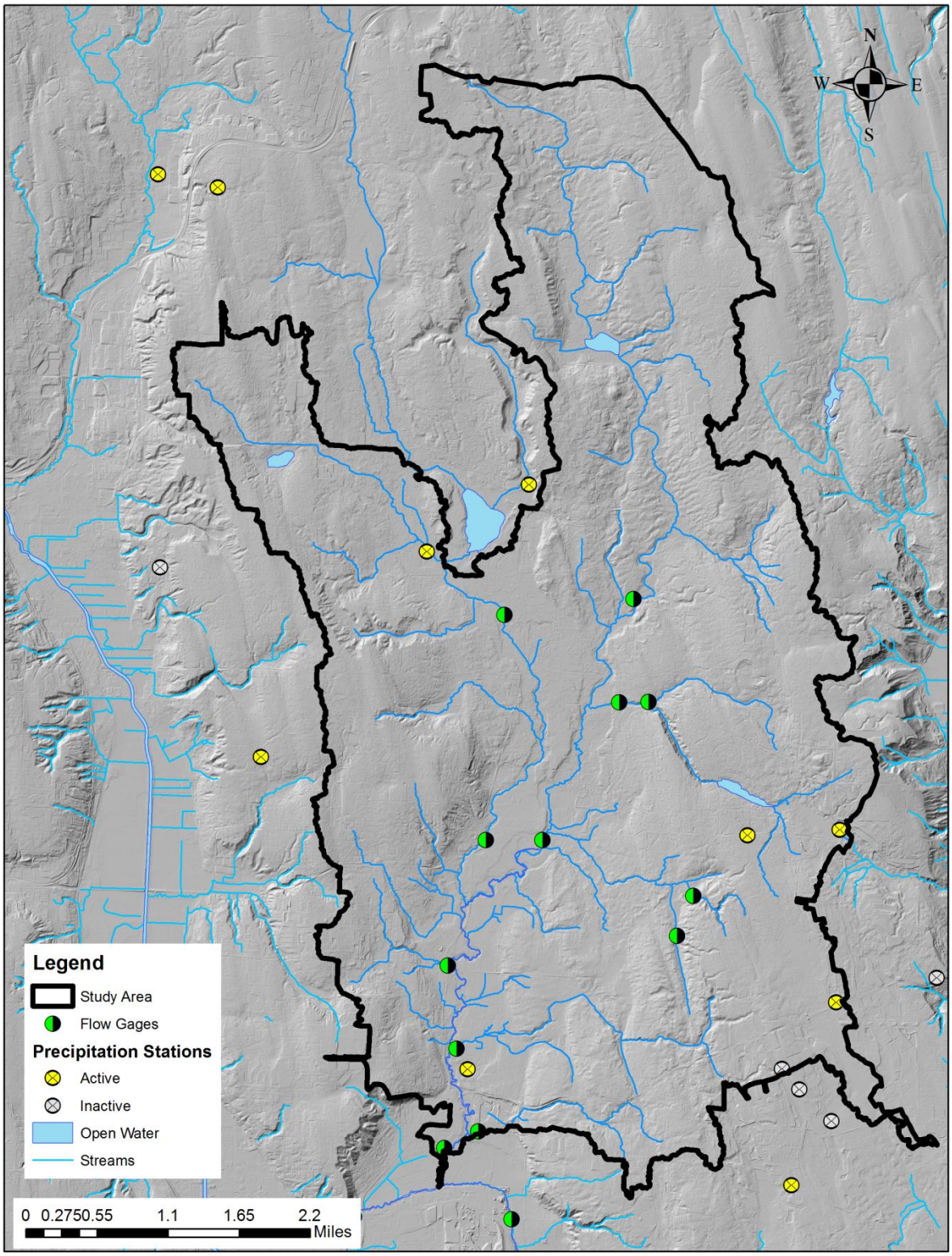

Figure 6. Bear Creek Study Area Stream Flow and Rainfall Monitoring Locations. Data from inactive stations may still be used.

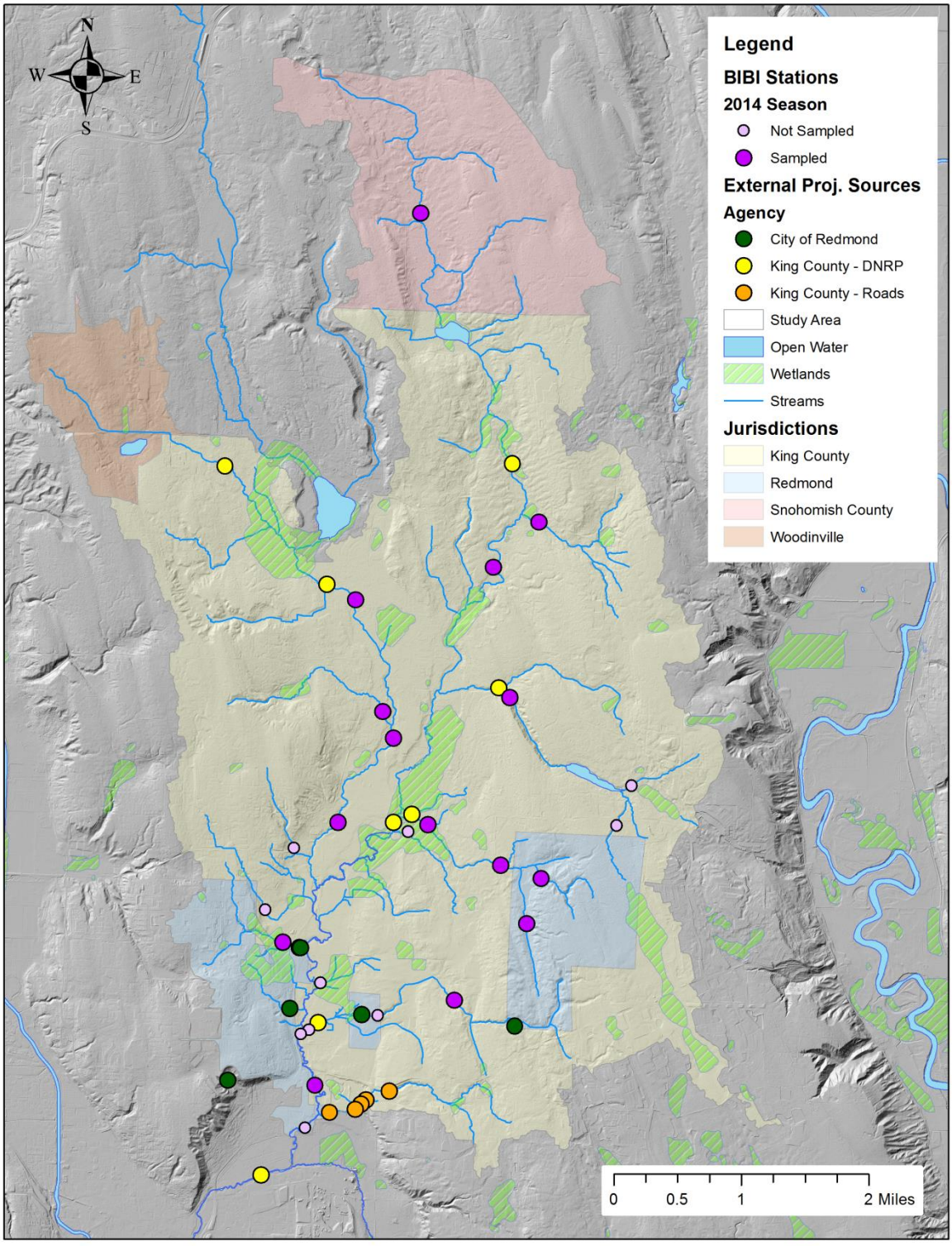

Figure 7. **Macroinvertebrate Sampling Locations. Forty potential sites - 28 sites have been monitored recently, 7 sites monitored by other agencies and 5 new sites added for this sampling. Some site conditions were prohibitive for collection.**

2.1.2 Task 1b: Flow and Rainfall

King County currently maintains ten continuous flow gauges in the Bear Creek study area, along with another gauge on Evans Creek, and a gauge on Bear Creek below the confluence with Evans Creek. Four more gauges have been installed (for a total of 12 continuous recording gages within the study area) focusing on tributaries to mainstem Bear Creek (Figure 6). There are eight monitoring stations recording rainfall with variable durations of data available that may be useful supporting development of the watershed model(s). Potential factors that may alter the number of gage installations and/or placement will be dependent on, for example, property access, adequacy of channel hydraulics, and site conditions for secure installation. Monitoring at these locations will be conducted for a least 12 months within 2014-2016. [S5.C.5.c.iv.(1).b]

2.1.3 Task 1c: Benthic Macroinvertebrates

Stream benthic macroinvertebrate monitoring data is available for 28 locations within the Bear Creek watershed study area. It is anticipated stream benthos macroinvertebrates will be monitored at these locations; other agencies (City of Redmond and King County Roads Division) are monitoring an additional 7 sites and potentially an additional 5 sites, for a total of 40 sites (Figure 7). Potential factors that may alter the number and location of benthos monitoring stations may be, for example, property access and/or adequacy of stream channel conditions. Sampling at these locations was conducted during late summer in 2014 and again in 2015. [S5.C.5.c.iv.(1).c]

2.1.4 Task 1d: Status of Aquatic Community

Fish community monitoring has been conducted in the Bear Creek watershed since 2009 as part of a grant project funded by the United States Environmental Protection Agency (USEPA). This monitoring effort uses electrofishing techniques to assess the fish community in streams. In addition, several studies have been conducted over the last several years that include salmonid monitoring (e.g., Kiyohara 2013 and 2015, WRIA 8 Chinook Salmon Conservation Plan) [S5.C.5.c.iv.(1).d]. Missing from these studies are measures of fish abundance characterizing juvenile chinook preference of stream channel habitat. Additional monitoring of stream reaches will be conducted cataloguing abundance of fish usage among different types of stream channel habitat. These data sources will be used to document the aquatic community of the watershed and help prioritize channel restoration projects based on preference of aquatic habitat by salmonids. The additional monitoring of surveyed stream reaches will be dependent on property access and navigability of stream. Possible limitations conducting the survey may include: poor weather conditions, property access, equipment failure, etc.

2.2 Task 2: Mapping

A series of maps will be prepared documenting watershed conditions [S5.C.5.c.iv.(2)]. These maps will focus on the types of information necessary for construction of a continuous rainfall/runoff hydrologic and water quality model of the watershed. Maps to be developed will include, at a minimum,

- Soil types will be based on GIS data available from United States Geological Survey (USGS), Natural Resources Conservation Service (NRCS), University of Washington, Snohomish County, and King County.
- Two sources of mapping data applicable for this watershed planning effort include University of Washington (2007[10]), and National Land Cover Database (2011[11]).
- Impervious land cover mapping data (2009[12]) is available to provide guidance during the determination of fractions of impervious surface for a given land use category.
- Slope of landscape will be generated from LiDAR based digital ground model elevations.
- MS4s and non-regulated public stormwater systems.
- Areas appropriate for special attention in regard to hydrologic and water quality impacts (e.g., on-site septic).

All Phase I & II MS4 mapping will be the responsibility of each jurisdiction to provide. If an area is incomplete in MS4 mapping, drainage area delineations will be based on topographic conditions. In general, drainage areas will be segmented into approximately 200 acre size catchments. Catchment sizes may be bigger or smaller depending on storm network mapping and identified significant hydraulic controls (e.g., stormwater detention ponds). Identified stormwater facilities will be individually evaluated for either explicit integration into the watershed models, as part of an aggregate conceptual storage routing in the catchments, or deemed non-significant and disregarded.

2.3 Task 3: Watershed Model Calibration

The relationship between land use and land cover, soil types, slope, stormwater management, weather, and stream flow and water quality in the watershed area will be modeled using Hydrologic Simulation Program – Fortran (HSPF). The model will be calibrated at a minimum for stream flow, temperature, dissolved copper, dissolved zinc, and fecal coliform bacteria [S5.C.5.c.iv.(3)]. Calibration will occur at locations defined in the Task 1 monitoring activity (see Figure 5 and Figure 6 for targeted locations).

Priority during calibration will be given to mainstem stations. Tributary monitoring stations will be used for guidance during the calibration process. Statistics characterizing model accuracy will be applied using each monitoring station's data as appropriate and may include: root-mean-square-error, Pearson correlations, coefficient of determination, relative percent differences, and mean and absolute errors. Metrics used for these statistics may include: annual and seasonal volumes, monthly, daily, and hourly simulated flow rates.

[10] University of Washington. 2007. Central Puget Sound 2007 Land Cover Classification. Puget Sound Regional Synthesis Model (PRISM). University of Washington.
[11] Homer, C.H., Fry, J.A., and Barnes C.A., 2012, The National Land Cover Database, U.S. Geological Survey Fact Sheet 2012-3020, 4 p.
[12] King County, 20110101, 2009 Impervious and Impacted Surface of King County Washington: King County, King County, WA.

Simulated average hourly water quality concentrations will be compared to instantaneous observed concentrations. Further guidance during water quality calibration will be simulating annual loading rates and comparing those to results (where applicable) from other studies in the region, then secondarily to studies conducted abroad.

Multiple flow metrics derived from the model output will be used to estimate the hydrologic limitations to benthic index of biologic integrity (BIBI). Metrics used will be based on recent studies conducted in the region by King County (2012)[13] and Horner (2013)[14]. The anticipated three metrics used to project BIBI scores are: high pulse counts, high pulse range, and PEAK:BASE, as developed in the Horner (2013) study. Two of the three metrics (high pulse counts and high pulse range) had the highest correlations among eight significant relationships defined in DeGasperi et al. (2009)[15]. After evaluating the watershed model accuracy simulating BIBI scores, projected BIBI scores will be based on the best fit of the regressions defined by King County (2012) and potentially Horner (2013).

Further analyses may be conducted to improve the established relationships between the flashiness metrics and BIBI scores. This may include, for example, new regressions based on additional years of data at the established 16 sites (DeGasperi 2009), additional sites and years collected within the Bear Creek study area, additional sites and years collected in the Puget Sound region[16]. If new regressions are developed and intended to replace the established ones (King County 2012, Horner 2013), methods and results will be discussed with Ecology and subject to Ecology's approval. [S5.C.5.c.iv.(4)]

Data available as part of this watershed plan, will span approximately between June 2014 and October 2015. Usage of data from monitoring stations with longer time spans of data will generally be limited to +/- 5 years adjacent to dates of data used to build the model (e.g., land use, stormwater infrastructure, etc.).

2.4 Task 4: Historic and Future Condition Modeling

Using the calibrated hydrologic and water quality watershed model, and relationships between flow metrics and BIBI, watershed condition will be assessed under a minimum of two scenarios [S5.C.5.c.iv.(4)]:

[13] King County. 2012. Stormwater Retrofit Analysis for Juanita Creek Basin in the Lake Washington Watershed. Ecology Grant: G0800618. Prepared by Jeff Burkey, Mark Wilgus P.E., and Hans Berge. King County Department of Natural Resources and Parks. Water and Land Resources Division. Seattle, Washington.
[14] Horner, R.R. 2013. Development of a Stormwater Retrofit Plan for Water Resources Inventory Area 9: Flow and Water Quality Indicators and Targets. King County Water and Land Resources Division, Seattle, Washington.
[15] DeGasperi, C.L., H.B. Berge, K. R. Whiting, J. J. Burkey, J. L. Cassin, and R. R. Fuerstenberg, 2009. Linking Hydrologic Alteration to Biological Impairment in Urbanizing Streams of the Puget Lowland, Washington, USA. Journal of the American Water Resources Association 45(2):512-533.
[16] http://pugetsoundstreambenthos.org/default.aspx

- idealized fully-forested conditions intended to be representative of undisturbed historic conditions; and,
- full build-out under existing or proposed comprehensive land use management plan(s) for the watershed.
    - Simulated future projections will include a baseline condition assuming no retrofits will occur to existing stormwater infrastructure projected to remain unchanged in the future.

Hydrologic response units (HRUs) defining types of land cover (e.g., impervious surfaces, grass, forest, etc.) for a given land use (e.g., low/medium/high density residential, commercial/industrial, etc.) will be based on previous studies conducted in the region (e.g., King County 2012[14], King County 2013[17]).

Rainfall runoff, water temperature, and pollutant loading rates resultant from the watershed model calibration process (Task 3) will be used as a basis for historical and future land use modeling scenarios. If during the watershed planning process new pollutant loading estimates become available from other more recent studies, they will be reviewed, but not necessarily included in this planning effort.

Stream flow, dissolved copper, dissolved zinc, temperature, and fecal coliform results will be compared to Washington State water quality standards, where possible. Estimations of average theoretical maximum BIBI scores will be presented using the average regression as defined in Task 3. Another possible measure evaluated may include the 90th percentile confidence interval. This method presumes no other limiting factors are present and BIBI can reach its maximum potential supported by improvements to stream hydrology.

2.5 Task 5: Evaluation of Stormwater Management Strategies

Improved stormwater management strategies will be assessed if water quality standards are modeled to not be met under future conditions in Task 4. The stormwater management strategies will be assessed relative to their modeled ability to allow for future water quality standards to be met, using the same hydrologic metrics, water quality parameters, and BIBI scores as used in Task 4 [S5.C.5.c.iv.(5)]. Additional measures of stream health are identified in Task 8. [S5.C.5.c.v]

Stormwater management strategies will be assessed using a combination of modeling techniques. Strategies will be assessed relative to how well they are projected to restore stream flow and water quality to being supportive of beneficial uses. The calibrated watershed HSPF model and the USEPA's System for Urban Stormwater Treatment and

[17] King County Science and Technical Support Section. 2013. Watershed Model Development for Water Resource Inventory Area (WRIA) 9 Stormwater Retrofit Planning Project. Prepared by Jeff Burkey, Science and Technical Support Section in Water and Land Resources Division, Department of Natural Resources and Parks. Seattle, Washington.

Analysis Integration (SUSTAIN) will both be used to assess effectiveness of stormwater management strategies. Stormwater strategies to be assessed will include:

- changes to development-related codes, rules, standards, and plans [S5.C.5.c.iv.(5).a]; and,
- potential future structural stormwater control projects consistent with NPDES permit obligations described in section (S5.C.6.a).

Examples of sources expected to be used to help define effectiveness for individual types of stormwater facilities include: Stormwater Management Manual for Western Washington (2012), King County Stormwater Management Manual (2009, 2016 version if applicable), outcomes from Stormwater Retrofit Analysis and Recommendations for Juanita Creek (2012), outcomes from Stormwater retrofit planning project for Green River Watershed (2013, 2014), Western Washington Continuous Simulation Hydrology Model (2012), and other case studies applying SUSTAIN to watersheds in the Puget Lowlands (e.g., case study[18] done in City of Federal Way jurisdiction).

Strategies will be developed that address which types of land cover should receive stormwater mitigation, and the types and amounts of stormwater mitigation different land covers should receive [S5.C.5.c.iv.(5).b]. Stormwater management strategies evaluated may also include:

- Basin-specific stormwater control requirements for new development and redevelopment as allowed by permit Section 7 of Appendix 1.
- Strategies to encourage redevelopment and infill, and an assessment of options for efficient, effective runoff controls for redevelopment projects, such as regional facilities serving increased densities of development, in lieu of individual site requirements that may include low impact development facilities.
- Retrofits of existing stormwater infrastructure projected to remain unchanged in the future.
- One or more stormwater management strategies other than those recommended which may be used for development of alternative implementation strategies.

2.6 Task 6: Implementation Plan and Schedule

Based on the stormwater strategies evaluated in Task 5, an implementation plan and schedule will be developed. The implementation plan and schedule will identify potential future actions to implement the identified stormwater management strategies, responsible parties, estimated costs, and potential funding mechanisms.

Alternative implementation strategies may be developed and included in the watershed plan that align with the participating non-lead Permittees' (i.e., Snohomish County, Cities of Redmond and/or Woodinville) planning and policies in the Bear Creek watershed study area.

[18] https://fortress.wa.gov/ecy/publications/SummaryPages/1303009.html

Cost estimates will be based on recent studies conducted (e.g., Stormwater retrofit planning project for Green River Watershed[19]) in the Puget Lowlands. Past stormwater mitigation and retrofit projects implemented by local jurisdictions in or near the study area may also be used to improve accuracy in cost estimates.

2.7 Task 7: Public Process

The project will incorporate input from stakeholders during the life of the project. Stakeholders will be informed of project status and input opportunities via a combination of web site updates, email updates, public meetings, and project workshops. It is anticipated that public outreach will occur on an annual basis, culminating with a solicitation of comments on a draft watershed-scale stormwater plan in the last year of this study. [S5.C.5.c.iv.(7)]

2.8 Task 8: Other Watershed Improvement Strategies

This task is optional as defined in the permit (S5.C.5.c.v). However, the goal of the permit is to restore stream systems capable of supporting their beneficial uses. Restoring a stream's hydrologic regime and water chemistry to more closely reflect forested conditions is critical, but may not be the only limiting constraint. Other environmental factors may also be suppressing response.

Four other factors that influence watershed conditions include, riparian vegetation, culverts, wetlands, and channel conditions. These will be investigated starting with review of previous studies. Each factor will be assessed to determine its present condition, and to identify potential strategies for improving conditions.

2.9 Task 9: Reporting

The watershed-scale stormwater basin plan will summarize results of the modeling and planning process, describe results of the evaluation of strategies under Task 5, and include the implementation plan and schedule developed under Task 6.

At the discretion of King County, annual status reports on the progress made on each task of this project may be submitted as part of King County's annual report.

2.10 Task 10: Project Management

The King County project team will meet on a periodic basis to ensure proper project communication. Project coordination with staff from other programs in King County, Snohomish County, the cities of Redmond and Woodinville, and with the Washington State Department of Transportation, will also occur. As part of the permit requirement

[19] http://www.kingcounty.gov/environment/watersheds/green-river/stormwater-retrofit-project.aspx

[S5.C.5.c.iii], the coordination and collaboration among the participating Permittees have been agreed upon as described in the submitted document[20] for permit compliance. The project manager will track project scope, schedule, budget and quality to ensure that all permit obligations are met.

Significant interim milestones outlined in this scope of work include:

- completion of a Sampling and Analysis Plan;
- completion of monitoring program;
- completion of watershed model development;
- development of watershed models characterizing current and future conditions;
- development of implementation plan;
- (optional) submission of annual reporting; and,
- submittal of the watershed-scale stormwater management plan.

It is anticipated there will be occasions when there will be a need to adjust work activities. Ecology will be notified of these changes and given updated target dates. Per discussions with Ecology and an email from Ecology dated June 5, 2014, changes to scope and/or schedule are pre-approved by Ecology unless there is an expectation of jeopardizing submission of a final watershed plan by the required date, or substantial changes in deliverables.

Substantive changes in scope will require pre-approval from Ecology. Some examples of changes considered substantive by Ecology and requiring pre-approval are:

- significantly changing monitoring sites;
- significantly changing sampling procedures or amount of field data collection;
- switching modeling software;
- changing the calibration procedure or basis for acceptance; and,
- changing assumptions for estimating future pollutant concentration or loads.

[20] King County. 2015. Coordination Plan for NPDES Phase I & II Bear Creek Watershed-Scale Stormwater Plan. Prepared by Jeff Burkey, King County Water and Land Resources Division; Bill Leif, Snohomish County Department of Public Works; Andy Rheaume, City of Redmond Department of Public Works; Tom Hansen, City of Woodinville Department of Public Works; and Dick Gersib, Washington State Department of Transportation.

3.0. SCHEDULE

The plan will summarize results of the modeling and planning process, describe results of the evaluation of strategies under Task 5, and include the implementation plan and schedule developed under Task 6. Tasks scheduled in this scope of work and as shown in Figure 8 are estimated target dates. Schedule adjustments may occur during the life of this project.

3.1 Permit Required Submittals

Schedule of deliverables for the Bear Creek watershed planning process are defined as follows:

- October 31, 2013—Notification to Ecology on selection of the Bear Creek watershed (Ecology was notified on October 31, 2013)
- August 13, 2015—A mutually agreed upon Coordination plan (submitted to Ecology July 29, 2015)
- November 4, 2015—Submission of this Scope of Work and Schedule (anticipated submission to Ecology by November 4, 2015)
- April 4, 2018—Submittal of the Bear Creek Watershed-Scale Stormwater Plan

3.2 Interim Activities

During the implementation of this Scope of Work, there are interim steps that need to be completed to successfully meet the permit compliance date for submittal of the Watershed Plan. Completion dates for each of the tasks below (and in Figure 8) are estimates and subject to change throughout the implementation of this Scope of Work.

- Task 1—Assessment of existing conditions and collection of new data.
  April 1, 2014 through September 30, 2016
- Task 2—Mapping.
  May 1, 2014 through September 30, 2016.
- Task 3—Watershed model development and calibration.
  December 1, 2014 through September 30, 2016.
- Task 4—Historic and future modeling.
  December 1, 2015 through September 30, 2016
- Task 5—Evaluation of stormwater management strategies.
  April 1, 2016 through February 28, 2017.
- Task 6—Implementation plan and schedule.
  June 1, 2016 through March 31, 2017.

- Task 7—Public Involvement.
  January 1, 2015 through December 31, 2017.
- Task 8—Other watershed improvement strategies.
  January 1, 2015 through October 31, 2016.
- Task 9—Reporting.
  January 1, 2014 through April 4, 2018
- Task 10—Project Management.
  January 1, 2014 through April 4, 2018

Revised October 9, 2015.	2014				2015				2016				2017				2018		
Task	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter
1. Assessment of Existing Conditions and collection of new data																			
Develop Water Quality Sampling Analysis Plan (QAPP)																			
Water Quality Monitoring																			
Water Quantity Monitoring																			
Benthics Monitoring																			
Assembly of data from previous studies																			
Obtain Data from other jurisdictions																			
Aquatic Uses																			
2. Mapping																			
MS4 & Facilities		Funded outside of this project																	
Soils																			
Landcover																			
Impervious																			
high water tables																			
Land Use																			
Sewered, OSS																			
Stream Channel Habitat																			
Aquatic Uses																			
Inventory Wetlands																			
Catchment Delineations																			
3. Watershed Model Development and Calibration																			
HRU development																			
HSPF: catchment delineations revised																			
HSPF: Channel Hydraulics																			
HSPF: Build Model																			
HSPF: Calibrate Water Quantity																			
HSPF: Calibrate Water Quality																			
SUSTAIN: Catchment Delineation revised																			
SUSTAIN: hydraulics																			
SUSTAIN: Treatment Train Design																			
SUSTAIN: Model Development/calibration																			
4. Historic and Future Condition Modeling																			
Develop Historical																			
Develop Future																			
5. Evaluation of Stormwater Management Strategies																			
Current stormwater guidelines																			
Necessary strategies to meet objects																			
6. Implementation Plan and Schedule																			
Identify High Priority Areas																			
Estimate Planning level costs																			
Identify potential funding sources																			
near-term project list																			
7. External Involvements																			
Partner Project Management Team Meetings																			
Stakeholder Workshops (approximate dates)							#1			#2					#3				
Public Involvement (approximate dates)					web				#1		#2				#3				
8. Other Watershed Improvement Strategies																			
riparian vegetation																			
bank stabilization/Channel habitat																			
Aquatic Community/fish passages																			
Aquatic Benthos																			
Wetland																			
9. Reporting																			
(optionsl) Annual Reporting																			
Coordination / Dispute Resolution Document																			
Scope of Work																			
Draft Watersehd Plan																			
PMT Review																			
Public Review																			
Final Plan																			
10. Project Management																			
Coorindation, Team Meetings, NPDES Permit Review, Agreements																			
Letter of notifications																			

Figure 8. Bear Creek Watershed-Scale Stormwater Plan Schedule.